Producibility Assessment of The General Specifications for Shipbuilding

U. S. DEPARTMENT OF TRANSPORTATION
Maritime Administration and
U.S. Navy

in cooperation with

Newport News Shipbuilding

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PRODUCIBILITY ASSESSMENT

OF

GENERAL SPECIFICATIONS FOR SHIPBUILDING

SHIP PRODUCTION COMMITTEE

PANEL SP-4

DESIGN/PRODUCTION INTEGRATION

TABLE OF CONTENTS

TABLE OF CONTENTS
(CONTINUED)

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

FIGURES

APPENDIX

SECTION I

INTRODUCTION

INTRODUCTION

The development and preparation of the specifications for building a ship to Navy requirements is a demanding task. As the governing technical document after the contract itself, the ship specifications content has a great impact on the technical performance of the resultant ship and it's construction cost. The specifications must be clear, concise and unambiguous to the maximum extent possible. Because of the increasing complexity of naval ships, and the need to reduce ship construction costs in the face of ever decreasing defense budget funds, a great deal of attention has been given in recent years to addressing ways to improve the producibility of ships. A Naval Sea Systems Command (NAVSEA) sponsored workshop, held in May 1991, produced a series of recommendations to improve the producibility of ships by the building yards. As an outgrowth of this workshop, one of the areas which has been recommended for scrutiny and possible change to improve ship construction and producibility is the ship specifications and the General Specifications for Ships of the U.S. Navy (GENSPECs).

The shipbuilding specifications are derived from many sources. The basic naval shipbuilding technical requirements are contained in NAVSEA Publication S9AAO-AA-SPN-0101/GENSPECs: General Specifications for Ships of the U.S. Navy (GENSPECs). This publication provides the basic technical requirements for new ships of all types including surface ships, submarines, aircraft carriers and other support

ships. It is the publication which is used as the technical basis for preparing individual Hull, Mechanical and Electrical (HM&E) ship specifications. Other technical publications, standards and specifications are also included as requirements. Together, these documents and the applicable portions of GENSPECs form the technical requirements of shipbuilding contract specifications.

BACKGROUND

The preparation of the ship specifications and the contract design are the first major functions in the overall shipbuilding process after the feasibility studies and preliminary design. As discussed in later sections, this effort is usually performed by a design services contractor, working under the technical direction of the NAVSEA Program Manager. For some programs, the contract design contractor has been the building yard. The importance of this involvement by the shipbuilder has long been recognized as contributing to reducing shipbuilding costs. Several discussions of this point in the literature over the past several years have stressed the positive effects on reducing the shipbuilding costs by having the shipbuilder involved in the ship specifications development and contract design. Some of these are:

> **"It should be emphasized here that what is at issue is not who does the contract design. The issue is the shipyard's need to control the design in order to ensure conformity with the yard's build strategy. Whether the contract design is prepared by an in-house design group or an independent naval architectural firm, the shipyard must have a building strategy that begins with and includes design and it must be able to communicate this strategy in negotiations with the ship owner over contract design."[1][1]**

[1][ ] Numbers in brackets indicate the reference source as listed in Appendix A.

and

> **"It is our experience that the greatest possibilities for productivity improvement are to be found at the design stage, not only at the time of making the working drawings, but in particular at the earliest stage of specifying the product. "[2]**

OBJECTIVES

The continuing need to reduce the cost of building ships in the United States is well known to all those involved in the industry. All facets of the shipbuilding process must be carefully reviewed to identify process changes which can be made to reduce the overall costs of shipbuilding. As the first major effort in the process, the preparation of the ship specifications and the contract design have an impact on the total process which follows. Ship specifications control the vast majority of the technical features by which ships are constructed and influence the managerial decision process to accomplish the work. Therefore, the process for developing the ship specifications and the contract design deserves careful scrutiny.

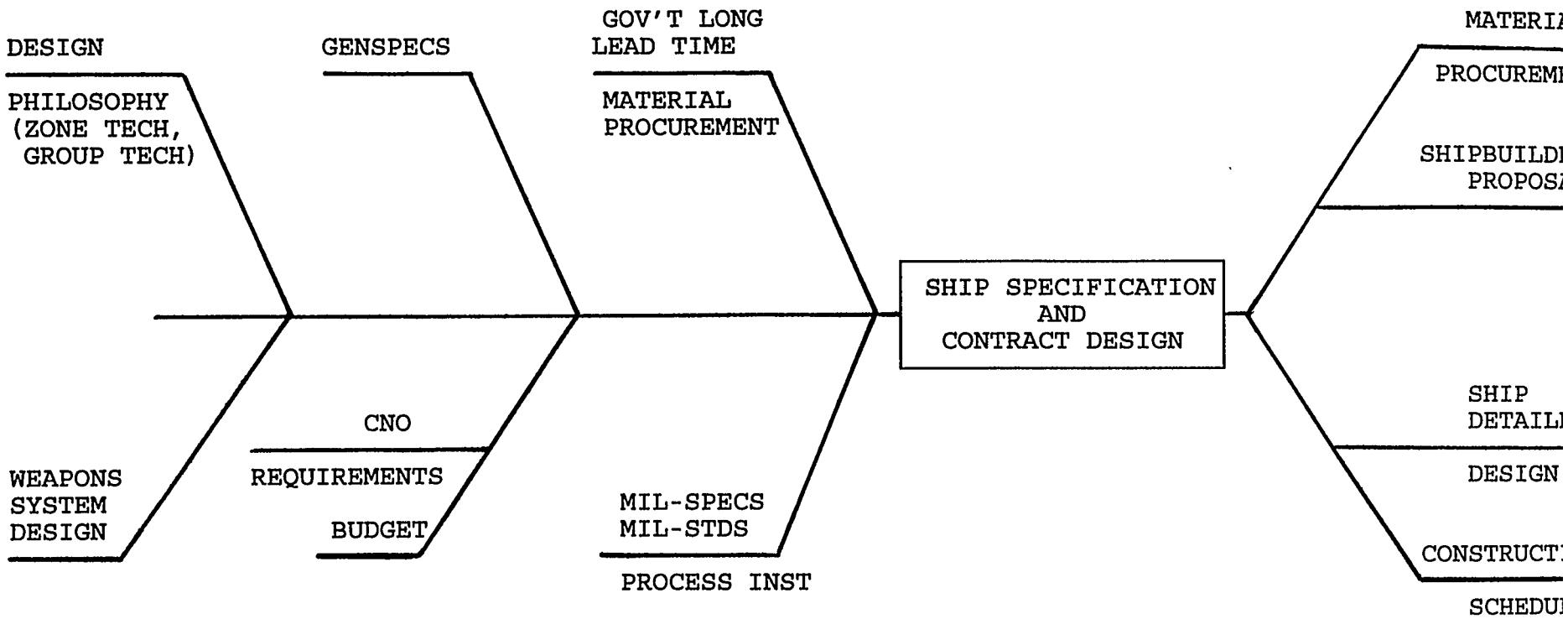
The objective of this assessment is to examine the process by which individual ship specifications are prepared by the U.S. Navy and identify those elements of individual ship specifications that have resulted in excessive and/or unnecessary ship building costs. The relationship and importance of the GENSPECs as the core technical document for constructing ships for the U.S. Navy were also studied. The ultimate objective is to identify improvements which can be made in the ship specifications development process, and to the specifications themselves, to reduce the overall ship producibility costs for shipbuilders.

TECHNICAL APPROACH

Our plan to accomplish this task follows the concepts of Total Quality Management (TQM). One of the basic principles of the TQM approach to improving the performance of a system is to analyze the process or processes involved in considerable detail. This allows an analysis of each activity or function in the process to determine its impact on the process as a whole. The process of design, contracting and construction of ships lends itself well to this form of analysis. The recently instituted NAVSEA Design, Acquisition and Construction (DAC) program is following this general philosophy.

In studying the shipbuilding process for U.S. Navy ships, the ship specifications and contract design are quickly identified as a major focal point in the process. As Figure 1 shows, the influencing events and forces preceding the finalizing of the ship specifications and contract design are all focused on this event. Once this event has been reached, the construction phase branches off and the actions to implement the construction phase can begin. Once the specifications are written and the contract design is completed, the best chance for effective, meaningful changes to reduce costs is past. This chain of events will be discussed further in Sections II and III.

In understanding the relationship of these events, it is also important to understand the role of the GENSPECs in the process. In later sections, we will address the overall specifications development process and the importance of the GENSPECs. Another issue to be addressed is whether or not the GENSPECs should be rewritten to support "producibility" improvement actions by shipbuilders. We will



SHIP SPECIFICATION FACTORS

FIGURE 1

address the role of the GENSPECs in shipbuilding and their position as the central technical document for naval ship construction.

INITIAL FINDINGS

After reviewing information from other studies of the shipbuilding process, our initial effort was to discuss the subject with NAVSEA Program Managers and technical codes as well as those involved in the shipbuilding side of the process. Discussions were held with NAVSEA Program Manager technical staffs for AEGIS cruiser, Minehunter and LHD programs. NAVSEA technical codes in the hull, mechanical and electrical areas were contacted to discuss the technical codes involvement in the ship specifications development process, as well as their roles in the maintenance of the GENSPECs. Supervisor of Shipbuilding, USN managers of ongoing naval ship construction contracts were contacted at Newport News and Pascagoula to discuss their view of the GENSPECs influence. Direct input from some shipbuilders was solicited.

Our initial findings pointed out that most of the parties involved in the process of preparing ship specifications understood their roles, but that the complexity of the process and the wide array of other parties involved was not well appreciated. The central role of the GENSPECs as the core technical document has been the recipient of most recommendations for improvement, even though the GENSPECs role in the process of preparing ship specifications was not clear to all parties. These findings served to re-focus our effort in this project somewhat.

In order to make any meaningful improvements in the ship specifications

development process it is important that the following areas be understood.

a. **The ship specifications development process, and the key decision makers and influences in the process.**

b. **The purpose of the GENSPECs as specified by NAVSEA, and the process by which GENSPECs are maintained and used.**

c. **The shipbuilders role in the process.**

d. **The impact of reductions in the defense budget on maintaining a solid NAVSEA technical shipbuilding engineering capability.**

SECTION II

SHIP SPECIFICATIONS DEVELOPMENT PROCESS

NAVSEA POLICY AND PROCEDURES

The policy and procedures for preparing the hull, mechanical and electrical portions of the ship specifications are specified by NAVSEA Instruction (Reference [3]). This instruction provides specific guidance to the ship program management offices as to how a set of ship specifications is to be prepared. While Reference [3] specifically addresses how the applicable requirements of the GENSPECs are to be incorporated, numerous other activities which have a direct influence on the ship specifications, with the exception of the Chief Naval Operations (CNO), are not mentioned. The influence of these activities is discussed later in this section.

This section describes the naval ship specifications development process as specified in the governing NAVSEA directives. We will also discuss the unwritten process, which is not well appreciated or understood, wherein numerous naval commands, activities and interested parties have a role in the process. In most cases, these other influences do contribute to the cost of building ships.

GENERAL SPECIFICATIONS FOR SHIPS OF THE U.S. NAVY (GENSPECs)

The GENSPECs is a publication which presents the hull, mechanical and electrical (HM&E) technical criteria for constructing ships for the U.S. Navy. Reference [4] specifies the scope of the GENSPECs and their intended use in the procurement of ships. To summarize, the intended scope of the GENSPECs is to:

a. Define the current standards, criteria and procedures associated with the design and construction of ships.

b. Contain technical and related requirements for the construction of ships and selection of machinery and equipment.

c. Contain only those general requirements which are reasonably permanent and generally common to all ship types.

d. Contain requirements which have proven to be attainable and are the minimum acceptable standards. Goals or requirements not within the state of the art are not included.

It should be noted that while the GENSPECs contain requirements applicable to new construction ships, the GENSPECs are not referenced directly in a contract for ship or equipment procurement. Rather, the GENSPECs is intended to be used as a guide in preparing materials of construction and components of machinery or equipment.

Reference [4] also prescribes the procedures for developing changes to the GENSPECs. In general, any naval activity or contractor may recommend changes to the GENSPECs based on their latest experiences on the development of new materials, processes, etc. These proposed changes are reviewed by the responsible NAVSEA technical code. The technical codes area of responsibilities are as shown in Reference [4]. Recommendations which require immediate implementation may be promulgated by instruction or GENSPECs amendment in anticipation of a total GENSPECs update.

While the policy of NAVSEA, as outlined in Reference [4], is to issue an updated GENSPECs annually, the current manpower restrictions being experienced in NAVSEA forces the delay of issuing an updated GENSPECs to once every two or three years in order to concentrate on current fleet technical issues.

SHIP SPECIFICATIONS

Ship specifications are prepared for each ship construction contract by NAVSEA as outlined in Reference [3]. The ship specifications are developed based on the technical requirements of the GENSPECs and other technical processes and procedures, as well as the unique aspects of the particular ship or class of ship being procured. The ship specifications are the governing technical document for the ship procurement contract, and usually take precedence over all other technical documents as spelled out in the precedence clause of the contract. With regards to the GENSPECs, the ship specifications will normally use the same general technical description as used in a particular section in the GENSPECs where the requirements apply. However, the GENSPECs are not considered a stand-alone document and, therefore, are not referenced as a technical specification as would a Military Specification (Mil-Spec or other technical standard. In a sense, the GENSPECs are invisible to the ship specifications user.

It became NAVSEA policy in the 1985 timeframe to develop the ship specifications using NAVSEA technical personnel. However, this has proven to be an unattainable goal for all but a few small ship construction programs, due to NAVSEA

manpower limitations. The lack of adequate technical personnel, both in quantity and with sufficient experience in technical fields, has forced the NAVSEA Program Managers to use the design agent contract as a means to get the needed technical support to prepare the ship specifications documents, along with the contract design drawings. In such cases, NAVSEA has fulfilled its technical contractual requirements by reviewing the design agent's products and providing overall technical direction and guidance.

Again, the GENSPECs are used as the base document in ship specifications development, and constitute the Navy's "corporate" technical requirements for the construction of ships and the procurement of equipment. As noted earlier, unless the GENSPECs requirements are rewritten and used in the ship specifications, the GENSPECs requirements do not become a part of the ship construction contract,

During the ship construction phase, a shipbuilder can obtain clarification of specifications from the Navy using a "Request for Clarification, Interpretation or Assistance" (RCIA) which is a detail design review problem report. These reports are submitted not only to request clarification of government design documentation but also to identify a potential discrepancy which requires additional investigation and direction from the Navy. On many shipbuilding contracts, RCIAs can number in the hundreds and are a very valuable information source for improving the specifications on follow ships.

HIERARCHY OF DOCUMENTS

In the preparation of the documentation to support a shipbuilding contract, an

order of priority is established in the precedence clause of each contract to clearly identify the contractual priority of documents. This is important in order to resolve differences, which arise during the execution of the contract, from conflicts which can exist between specifications, drawings and other referenced documents. As noted earlier, the ship specifications are the primary technical requirements document in a ship construction contract (Reference [3]). As such, the ship specifications takes precedent over contract drawings and other technical documentation unless otherwise stated in the contract document. The GENSPECs per se have no standing in a ship construction contract except as may be reflected in the ship specifications.

SHIP SPECIFICATIONS DEVELOPMENT PROCESS

To ensure an understanding of the role of the GENSPECs in ship construction, a brief description of the development of a typical ship's specification would be useful. When beginning the development of the specifications for a new ship, a Program Manager is normally assigned to manage the process. In the past, the ship specifications development was usually performed internal to NAVSEA. However, as programs have grown and NAVSEA personnel resources have diminished, design contractors have been used to obtain private sector design assistance. Reference [3] provides specific responsibilities for executing this process.

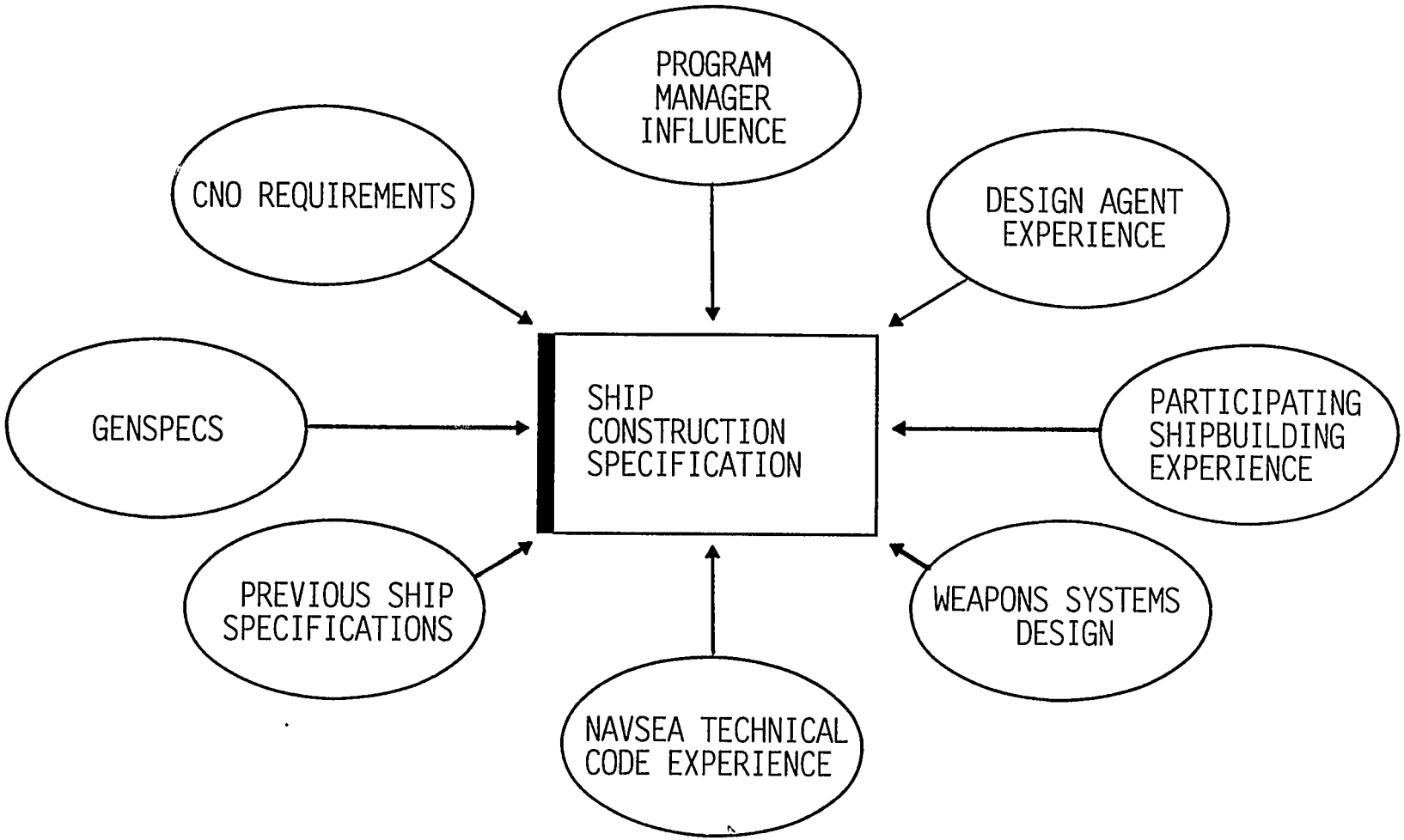
As sections of the ship specifications are produced, they are processed for review by the Program Manager's team as well as by the cognizant NAVSEA technical code. Marked-up ship specifications sections are reviewed by the Program Manager

and his design team and differences are resolved. As stated in Reference [3], GENSPECs are not referred to in the ship specifications. If portions of the GENSPECs are applicable to the individual ship specifications, then the GENSPECs section is re-written directly into the ship specifications.

INFLUENCES ON SHIP SPECIFICATIONS DEVELOPMENT

In examining the factors which influence the development of ship specifications as shown in Figure 2, we are presented with an interesting perspective as to the role of the GENSPECs on the development of the individual ship specifications. Of all the influences on the resultant ship specifications from program to program, flight to flight and year to year, the GENSPECs is the only factor or influence which remains constant. All of the other influences shown in Figure 2, and there are others, changes from year to year or program to program. Consider the following comments for each element in Figure 2:

- **The GENSPECs is a core document of basic shipbuilding requirements by system or Ship System Identification Code (SSIC) applicable to all classes of ships and submarines. Any Program Manager and design agent can refer to GENSPECs and find the official NAVSEA design requirements for any system or equipment, subject to any changes in progress. This is a solid reference available year to year and program to program.**
- **CNO Requirement - These requirements change from ship class to ship**



FACTORS INFLUENCING PREPARATION OF SHIP SPECIFICATIONS

FIGURE 2

class. They also may be influenced by the personalities involved in the development of the ship characteristics and often reflect the current political situation influencing the budget for the ships. This element clearly changes with every program or new ship procurement.

- **Program Manager Influence - Each Program Manager brings a different background to the process. The Program Manager has overall responsibility for the development of the ship specifications. He must oversee the inputs from the NAVSEA technical codes and other organizations to ensure over zealous or unnecessary requirements do not appear where they are not needed. The Program Manager must maintain strict controls in order to prevent "pet projects" or other unnecessary requirements from being added which usually lead to increased costs. Some Program Managers even have developed some limited in-house engineering capability in addition to the NAVSEA engineering codes. Some rely on their contracted design agent to prepare the shipbuilding specifications. And finally, some Program Managers task a shipyard for design support. In each, the budgetary impacts, the types of ships, etc., all provide some variation in the resultant ship specification.**

- **NAVSEA Technical Code Experience - From year to year and program to program, the technical expertise of the NAVSEA technical codes assigned to review the ship specifications will vary as people change and the staff manpower level changes. This can present a difference in how**

some aspects of the technical requirements are implemented.

- Design Agent Experience - Almost every shipbuilding program now involves a different design agent in support of the responsible NAVSEA Program Managers office. Their corporate background and experience, as well as the experience of the personnel they assign to the task of preparing the shipbuilding specifications, present some variation in the final product.
- Shipbuilder Participation - Not all shipbuilders get involved with all programs. Thus, for each NAVSEA program office where the shipbuilder is involved in the detailed design and/or specifications development, each one brings a different agenda, capability and background to the process.
- Combat System Design - Almost every NAVSEA shipbuilding program supports a different combat system. Different combat system suits bring different Space and Warfare Systems Command (SPAWAR) design codes, different weapons systems contractors and different system design considerations to the process. Thus, each program is faced with variations in the ship specifications package resulting from the combat systems suit. These variations may impact the hull, mechanical and electrical specifications which are derived from the GENSPECs.
- Previous Ship Specifications - Frequently, the Program Manager will use a similar set of ship specifications from an earlier design as a starting point for preparing a new ship specifications. This is a logical, cost

effective starting point. Again, from program to program, these previous ship specifications will have some variations. This may be due to technical changes, shipyards involved, etc., but they will present some variation to the outcome of the ship specification development process.

When we review all of these elements which have an influence on the preparation of a set of ship specifications, the only element which is a constant across all programs is the GENSPECs. All others present some variations and different influences on the particular design. The GENSPECs is the one document which ensures that the ship's hull, mechanical and electrical systems begin from one governing design criteria applicable to all naval ships. This is one of the reasons we do not recommend proceeding with attempts to make the GENSPECs a production oriented document. The GENSPECs should continue to be the core specification reflecting general design criteria and applicable system performance standards. Production oriented shipbuilding specifications can and should be developed where possible to fit with the shipbuilders construction strategy. However, not all shipbuilders work to the same construction strategy. Thus, it is not practical to orient the GENSPECs to any one shipbuilders process for construction.

OTHER TECHNICAL REQUIREMENTS

The ship construction specifications invoke many Navy process instructions and procedures for the construction of ships as referenced requirements. These include welding standards, piping fabrication standards, non-destructive testing requirement and quality assurance system criteria. Because these fabrication and process

requirements have application to the maintenance and overhaul of ships as well as for their construction, they are stand-alone process requirements which are invoked in contracts and specifications where applicable. Frequently, these processes, procedures and requirements are mistakenly considered as originating in the GENSPECs. GENSPECs provide the technical requirements for ship system performance but do not contain process or fabrication requirements. As a matter of fact, all of the references in GENSPECs for processes applicable to welding of structure, fabrication of piping systems, machinery fabrication and inspection and casting requirements for all surface ships, surface craft, submarines and auxiliary ships are contained on one page of the GENSPECs.

In the practical world of ship construction, the shipbuilders' preparation and qualification of fabrication processes, and the interpretation of the quality assurance requirements for these processes, are a large part of the technical disputes between contractors and the Navy. These arguments over specifications interpretation may be valid and need to be addressed in some forum, but not as they relate to the GENSPECs.

SECTION III

SHIP SPECIFICATIONS DEVELOPMENT PROCESS AS FOUND

GENERAL

Through discussions with NAVSEA and SUPSHIPS personnel, we found the control of the GENSPECs and the process of developing new ship specifications to be generally in accordance with the NAVSEA governing instructions, References [3] and [4]. Considerable management attention and effort has been and is continuing to be expended by NAVSEA to improve this procedure, as well as other areas affecting the ship construction process. Some of these areas of responsibility and actions found to be underway are discussed further in this section.

GENSPECs CONTROL PROCESS

The GENSPECs are being controlled and managed, as described in Reference [4], under the cognizance of the NAVSEA Chief Engineer (NAVSEA 05). GENSPECs are maintained on a digital data base for ease of updating and distribution. The NAVSEA technical codes contacted understand the importance of maintaining the GENSPECs as a core technical document, and provide the section reviews and updates as workload permits.

While the responsibility for maintaining the GENSPECs technically current belongs in NAVSEA, all users of the GENSPECs are afforded the opportunity to submit recommendations for change or correction as outlined in Reference [4]. The identification of areas in the GENSPECs where change is needed is encouraged from sources such as shipbuilders, the fleet, the Board of Inspection and Survey and other

users of ship specifications and GENSPECs.

NAVSEA DESIGN ACQUISITION AND CONSTRUCTION (DAC) GROUP

In 1990, NAVSEA initiated a project to improve the ship Design, Acquisition and Construction (DAC) of ships for the U.S. Navy. Through a series of workshops with NAVSEA personnel, shipbuilders and design contractors, a long list of recommended actions was developed resulting in a Strategic Plan for improving the DAC process. Since this effort was initiated in 1990, the dramatic change in the world situation has had a profound impact on the ship design process due to budget reductions. Among the many initiatives in the DAC are several recommendations which could help in improving the specifications development process. One recommendation has been to improve the GENSPECs and their application to ship producibility, one of the subjects of this study. A NAVSEA Process Action Team (PAT) has also been assigned to address this issue.

The NAVSEA plan for improving the DAC process as contained in Reference [5] presents a formidable challenge to NAVSEA and the Navy to effect improvements in the shipbuilding process. The reductions in the shipbuilding program and other budgetary impacts on NAVSEA only make achieving significant results more challenging.

The NAVSEA DAC plan contains several recommended actions aimed at improving the timeliness and quality of the design information provided to the shipbuilders. However, these recommendations generally refer to specific equipment

nomenclature, combat system requirements and other data, which is normally developed either during the contract design process or provided to the shipbuilders as Government Furnished Information (GFI). In passing, the GENSPECs are cited as needing improvement in their quality, but no specific actions or recommendations to address the comment are presented in the NAVSEA DAC Strategic Plan, Reference [5].

PROGRAM VARIATIONS

The NAVSEA procedure for preparing, reviewing and issuing ship specifications is contained in Reference [3]. However, each ship Program Manager is faced with different problems in issuing a shipbuilding contract and the accompanying ship specifications and contract drawings. The major issues facing the Program Manager are the cost of preparing these documents and meeting the required schedules to support the program.

Because of the many ship types assigned to the various Program Managers (e.g., AEGIS, Carriers, Amphibious, Mine Warfare) and the small number of shipbuilders which each Program Manager now deals with, each program's design effort is structured to suit the ship type, design contractor and shipbuilder. This is to be expected of any prudent program management. To reduce design costs in the program, existing documents are used to their fullest. Previous contract drawings can be re-issued or updated with minimal cost. Existing ship construction specifications, which are familiar to the shipbuilders who will be the probable builders of the new

ship being designed, are reviewed and updated to include new requirements, changes in GENSPECs and other governing documents.

Program Managers for some ship programs, such as the Minehunter, LCAC and other unique classes of ships find the GENSPECs to be of little or no use because of unique materials used or other design considerations.

CONTRACT DESIGN CHANGE ORDERS

In the process of determining the extent to which Program Managers are being impacted by defective or incomplete specifications such as GENSPECs, we investigated the area of contract change orders in the AEGIS CG-47 cruiser program, which is a mature shipbuilding program. NAVSEA (PMS400) personnel provided the authors with a report which categorizes 4,759 Engineering Change Proposals (ECPs) for the CG-47 building program as shown in Figure 3. The Design Improvement Categories were broken down into six sub categories as shown. Overall, design improvements have been 22.9 percent of the total number of ECPs and represent 26.7 percent of the total cost of changes for the AEGIS CG-47 class program. These numbers are subject to more detailed analysis, but in the aggregate they give a reasonable picture of the impact of design changes on the growth in the ship construction contracts. Reviewing the categories of design changes in Figure 3, one can reasonably estimate that the impact of any imperfections in the GENSPECs would be relatively small compared to other sources of contract changes.

The data presented in Figure 3 is applicable to the AEGIS CG-47 class program only. This is a mature shipbuilding program with a significant number of ships. The

CG-47 CLASS CHANGE CATEGORIES

CATEGORY	NO OF ECPs	PERCENTAGE OF TOTAL COST
I. MISSION CAPABILITY		
IA MISSION CAPABILITY REVISIONS	47	9.63%
IB CHANGES DUE TO MISSION CAPABILITY REVISIONS	36	3.87%
II. INSURV	482	9.93%
III. NAVY WIDE DIRECTION	22	1.61%
IV. CERTIFICATION ITEMS	32	2.06%
V. COMBAT SYSTEM	520	18.84%
VI. SAFETY ITEMS	91	3.70%
VII. GFE/GFI	171	0.90%
VIII. CANIBALIZATION OF EQUIPMENT	2	0.31%
IX. STOWAGE REQUIREMENTS	23	0.95%
X. DESIGN IMPROVEMENTS		
XA R&M CHANGES	20	0.80%
XB IMPROVED MAINTENANCE	144	4.03%
XC REQUIRED/GOOD	475	12.05%
XD DUMB	53	0.47%
XE WON'T WORK	86	2.27%
XF HM&E	26	7.04%
XI. CCRs	86	3.11%
XII. ADMINISTRATIVE	757	1.22%
XIII. WEIGHT & KG REDUCTION	90	3.13%
XIV. FOLLOW YARD DRAWING CHANGE	18	0.19%
XV. TEST CHANGES	119	3.30%
XVI. VENDOR ECPs	65	1.64%
XVII. OTHER	2	0.003%
XVIII. CONVERGENCE	76	5.91%
XIX. SHOCK	68	3.03%
TOTALS:	3,510	100%

3,510 = APPROVED ECPs
590 = CANCELLED ECPs
307 = DISAPPROVED ECPs
317 = WITHDRAWN ECPs
35 = ECPs STILL IN PROCESS
4,759 = TOTAL L3 ECPs

FEBRUARY 1992

FIGURE 3

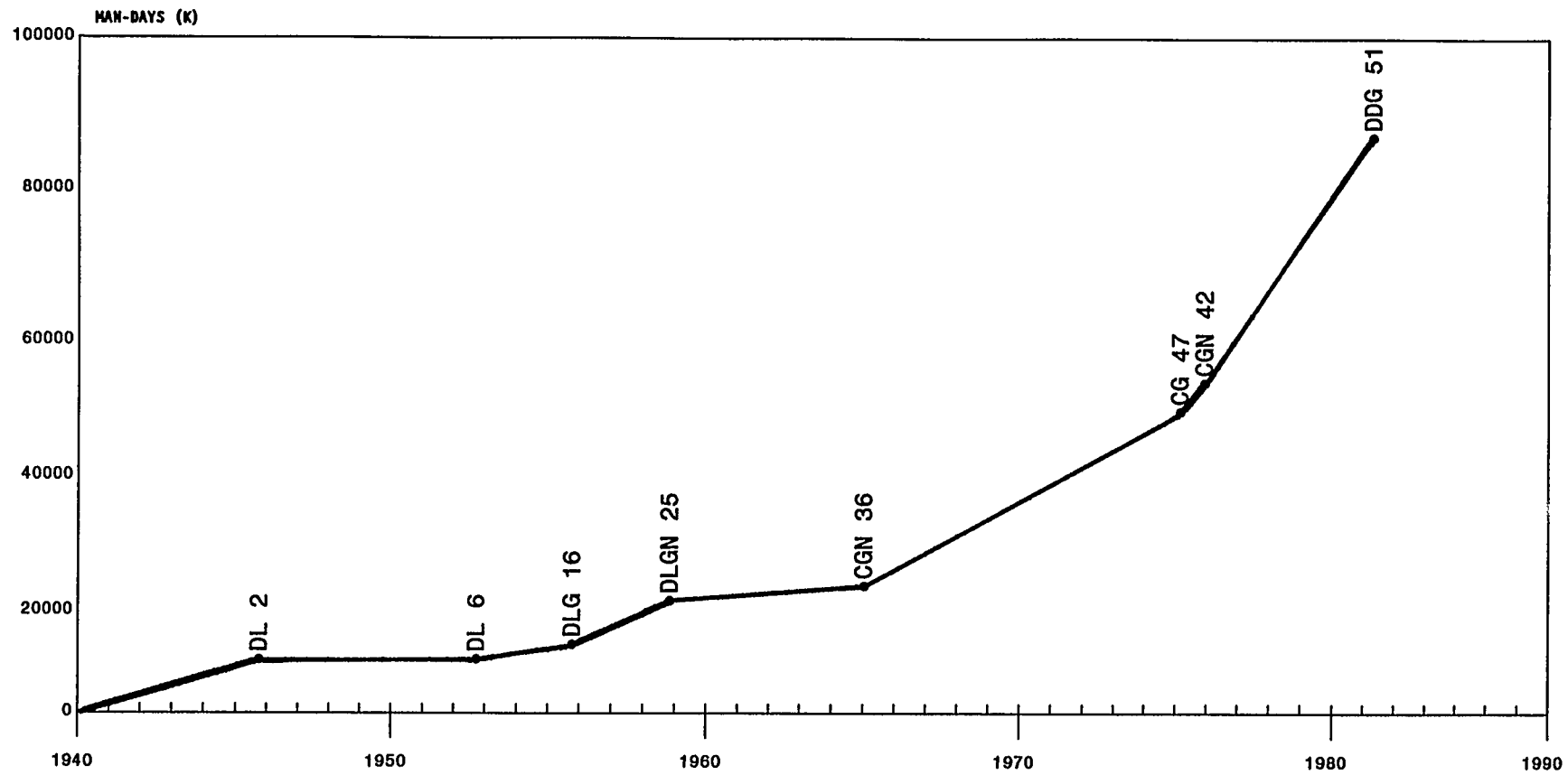
percentages for the various categories in Figure 3 are going to vary from program to program depending on a number of factors such as the size of the program, weapons systems complexity and the previous ship designs used as a reference.

Figure 3 provides several areas for future study of improvements in the specification development process. As the data shows, approximately fifty percent of the contract changes issued on this large, well engineered, program have resulted from Combat Systems changes, INSURV requirements, Required Design Improvements and Mission Capability Revisions. All of these categories contain changes to the contract deemed to be required after the detail design was completed. They are costly and reflect deficiencies in the intended detailed design. The originators of these contract changes have had an impact on the cost of ship construction and, at first glance, are largely influences outside the control of the Program Manager. This is an area which should be investigated for possible cost reductions.

CONTRACT DESIGN COSTS

One of the major areas of concern over the past decade has been the ever increasing design costs for ships. The NAVSEA DAC study group has investigated this problem and presents their findings in Reference [5]. Figure 4, which is taken from Reference [5], shows the sharp increase in ship contract design costs beginning in about 1967.

Except for the automation of the GENSPECs data base, the concept and the function of the GENSPECs, the HM&E design requirements, have had little change over the past twenty years. Efforts have been made occasionally to have the



CONTRACT DESIGN EFFORT FOR MAJOR SURFACE COMBATANTS
FIGURE 4

GENSPECs become more detailed and provide specific design criteria for various systems. As these efforts usually resulted in more claims or REAs, the GENSPECs was in most cases changed back to a basic core design document to support all ship classes.

The NAVSEA DAC has attempted to address the question of increasing design costs in their DAC strategic plan, Reference [5]. While not being able to devote too much effort to that area, they have noted the long duration of contract design phase which in itself is a cost driver. One concept to consider is the change in the relationship between the ship with its support systems and the installed weapons system as a key element in the increasing costs of contract design. In the 1950s and 1960s the weapons systems were stand-alone gun systems, anti-submarine warfare systems and surface to air missile systems with little or no system integration. HM&E designs were relatively standard, had been well shaken out and were adequate for the purpose. Beginning in the late 1960s, the ability to integrate the weapons systems greatly increased their capabilities and effectiveness, and also increased the complexity of the ship construction design process. The surface ship was transformed from a hull and power plant which carried several stand-alone weapons systems into a complex computer integrated weapons platform. The complex weapons system, with its increased support system requirements, became the critical path for the design, construction and delivery of ships. Because of the long standing requirement to provide the latest weapons system capability for the fleet, weapons system design information has, at times, been provided late in the design process.

This has impacted the HM&E support systems design resulting in design rework and increased contract design costs. This would not have been all bad if there was a valid requirement to provide the very latest state-of-the-art weapons systems to the fleet. However, all concerned must recognize the tradeoff in design and construction costs, as HM&E design efforts are held up awaiting weapons systems design completion.

SECTION IV

CONCLUSIONS AND RECOMMENDATIONS

DISCUSSION

This section presents the conclusions reached as a result of this study and presents recommendations for future actions. The focus of the recommendations is to pursue possible changes in the process of developing ship specifications for building ships for the U.S. Navy, while ensuring that the technical requirements upon which the ship specifications are based remain sound.

CONCLUSIONS AND RECOMMENDATIONS:

1. CONCLUSION

In the preparation of a set of ship specifications, the process followed by NAVSEA and the Program Manager is not specifically defined. The usual practicers to proceed using previous ship specifications, guidance from OPNAV sponsors and the Program Manager, along with current design practices. Portions of the GENSPECs may be used depending on the circumstances. If they are used, the GENSPECs provide design limits and operating parameters but are not used verbatim in the ship specifications.

DISCUSSION

In the process of developing a set of ship specifications for a new class of ships, controlling the costs of the design process is an important consideration. As a result, the Program Manager is forced to find ways to produce an acceptable set of ship specifications while staying within some budgetary limits. To do this often requires using existing ship class specifications as a baseline to be updated or modified and making design tradeoff decisions to produce a ship platform specification which can meet the mission requirements and yet be constructed to shipbuilding standards within the budget.

In the process, the GENSPECs will usually not be quoted as a reference but the appropriate specifications section will be lifted and inserted in the ship specifications. Thus, the GENSPECs provide a baseline design criteria for the new ship specifications,

which are used when the Program Manager and the design agent want to use the GENSPECs requirements. They are not routinely used in all situations.

In most Navy shipbuilding programs, the GENSPECs are used as a reference document from which to extract specifications requirements for sections where the design agent decides to use them. When the design agent and the Program Manager decide to use another criteria or modify a GENSPECs provision, that course of action is within the Program Managers purview.

Using the GENSPECs in this manner is their best use in the process. However, invoking the GENSPECs as a cause for increasing costs of construction without understanding the total process is inappropriate.

RECOMMENDATIONS

The primary concern is that all parties understand the process of developing a set of individual ship class specifications and how the GENSPECs are used in that process. While major portions of the GENSPECs may be quoted in a ship's specifications, the GENSPECs usually are not referenced; and the extent to which a ship specifications section contains GENSPECs wording, as well as additional wording from other sources is not apparent to the specifications user without further research.

2. CONCLUSION

Improvements can be made in the ship specifications process to help reduce the costs of building ships. This requires reviewing all factors that affect the process including, but not limited to, all technical documents and policies and procedures which ultimately are included in the ship specifications.

DISCUSSION

All NAVSEA technical procedures, processes, instructions and publications, such as GENSPECs, now have a process for routine feedback of proposed changes. However, these routine changes and/or recommendations usually take a long time to work their way through the system. Specification change proposals from shipbuilders usually go through the local SUPSHIPs, a Program Manager, and several technical reviews before they get serious consideration. Within this arduous process, visibility is soon lost and time frequently overtakes the process.

The need to address all possible sources for reducing the costs of building ships, suggests that a higher level effort, possibly under the sponsorship of the NSRP, and one directly involving the shipbuilders, is needed to address cost drivers in the ship specifications. These may include any and all technical requirements including GENSPECs, policy directives and "good shipbuilding practices".

This is not a small undertaking. Such a project under the NSRP would request all shipbuilders to identify the key problems they have with specifications. Once received, the NSRP would circulate the problems identified for comment to other

shipbuilders. The resultant product should be a composite listing that is technically supported. It could then be prepared for submission to NAVSEA through the NAVSEA Design, Acquisition and Construction (DAC) process for comment and action. This program within NAVSEA, dedicated to improving the shipbuilding process, would be better able to respond to a manageable number of specifications problems.

Once the first set of issues has been addressed and feedback received by the NSRP and the shipbuilders, a second round of issues would be developed using the same process. In this manner, the number of significant cost issues in the ship specifications would be surfaced from the shipbuilders through the NSRP and into NAVSEA for action. Once the process has completed two or three cycles, the cost benefits of such an effort would be greatly reduced and the effort could be terminated. The remaining items could be submitted through the normal specifications improvement process.

RECOMMENDATION

The NSRP establish a project to manage a ship specification cost driver identification process between the shipbuilders and the NAVSEA DAC. One strong candidate for study is the Recurrence of REIAa within Programs and across different Programs. The project would solicit inputs directly from the shipbuilders and address any and all specifications where changes could result in lower ship construction costs.

3. CONCLUSION

GENSPECs are maintained as a core technical document by NAVSEA 05. The GENSPECs are updated about every two years to reflect changes in technology, policy changes, feedback from ongoing new construction programs, and input from building yards and SUPSHIPS. The GENSPECs are not a real time, document which is directly applicable as the reference for new ship procurement. Each section must be carefully reviewed for its applicability to a specific ship design.

DISCUSSION

The GENSPECs serve a significant and useful purpose in being a document which contains the Navy's baseline technical criteria for new ship design. In this manner, there always exists a baseline from which to begin in defining the current technical requirements applicable to each area of new ship design. As fewer and fewer new ship class designs are being started, this basic reference standard will become increasingly more valuable as the expertise in new construction design in both the public and private sectors diminishes.

RECOMMENDATION

NAVSEA should ensure that the procedures for maintaining the GENSPECs reasonably current, as outlined in NAVSEA INST 9070.4, are followed.

4. CONCLUSION

NAVSEA does not have the capability in house to develop a major shipbuilding program specification or design without outside contractor support.

DISCUSSION

During the early 1980s there was a strong effort made by NAVSEA to reestablish a capability within the Navy to produce an in-house ship design. This plan was discussed at great length at the 1991 NAVSEA Ship Design, Acquisition and Contracting process Improvement Workshop II in Richmond, Va (Reference [6]). NAVSEA'S desire to re-establish such a capability does not appear to be feasible for several reasons. First, the NAVSEA personnel reductions due to the budgetary actions prevents developing new engineers capable of performing ship design tasks. New hires made in 1990-1991 have reportedly been laid off or have resigned. Secondly, the number of new ship designs being proposed in the Navy's shipbuilding programs is small and does not support the start-up of a new ship design cadre of engineers. Thirdly, while the concept of NAVSEA performing contract and detail design work in-house is laudable, the contractual risks of providing design products as Government Furnished Information to shipbuilders without a well qualified and experienced design team in NAVSEA would result in significant contractual problems. In the current budgetary and naval shipbuilding climate, the Navy would be better served if NAVSEA used their limited engineering resources to perform a design review function for new ship designs.

RECOMMENDATIONS

Contract design and detail design efforts for Naval ships should be performed by shipyards or qualified agencies under the specific ship Program Manager. NAVSEA technical codes should continue to be the repository for the Navy's design requirements which are in the GENSPECs and other standards. The best use of the NAVSEA engineering talent for new ship design is in a design review capacity.

5. CONCLUSION

Because of the claim or Request for Equitable Adjustment (REA) environment which exists between the shipbuilders and the Navy, NAVSEA technical codes have been reluctant to make GENSPECs paragraphs too specific but rather provide general guidance. This leaves the burden on the shipbuilder to develop the specific requirements intended by the specifications. This protects the NAVSEA technical code from being accused of writing a specification upon which the shipbuilder can base a claim or REA.

DISCUSSION

In the past, NAVSEA has made an effort to apply greater specificity to the GENSPECs such as pump-motor horsepower or piping sizes. This type of detail was then included in the individual ship class specifications and invoked for ship detail design or ship construction. In some applications, these detailed design criteria had to be changed for various reasons. When that happened, the contractor submitted REAs based on defective ship specifications which lead back to the GENSPECs. The cognizant NAVSEA technical code was then admonished for writing a defective GENSPEC.

This reaction to a "precise" GENSPECs section has resulted in the general tendency on the part of the NAVSEA technical codes to write general, generic GENSPECs sections which provide broad guidance to the design agents. This generalized approach may be more appropriate because it forces the design agent to

do a thorough detailed design and select the best equipment and material sizes for that design. The design agent is then making a careful design review of the specific shipboard application and not arbitrarily invoking GENSPECs parameters that may be outdated or in appropriate.

The current method of using the GENSPECs to provide a solid technical reference for the Navy's shipbuilding specifications appears to be the proper role for the GENSPECs. Contract and detailed design procedures then have a solid, historical and experience based design criteria to work from which provides design limits while providing significant latitude to the design agent and the shipbuilder.

RECOMMENDATIONS

The GENSPECs should contain design limits and parameters which will give contract and detail design agents the guidance needed to develop a specific ship or class specification. As the time between new ship design efforts lengthens and the overall expertise in naval ship design is reduced by the expected budgetary actions, the GENSPECs will be more and more valuable in fulfilling the technical baseline role for future design efforts.

6. CONCLUSION

Contract change data from the AEGIS CG47 Class cruiser program appears to indicate that over one half of the changes originate from sources beyond the Program Manager's control; i.e., not caused by a defective specification.

DISCUSSION

In our effort to reduce the costs of constructing ships for the U.S. Navy through improving the ship specification development process, one of the areas to be evaluated is the source of contract changes. Figure 3 presents the source of contract changes for the CG47 class AEGIS cruiser program. This information shows that fifty-six percent of the cost of constant changes in this multi-ship program originated from five sources:

a. **Mission Capability Revisions**

b. **INSURV inspections**

c. **Combat Systems**

d. **Design Improvements (Required/Good)**

e. **Design Improvements (HM&E)**

All of the areas are controllable. However, these changes are sponsored by people or agencies trying to improve the product after the initial specifications were completed, approved and issued.

This is a significant body of information which can be studied to identify improvements which can be made in the specification development process.

RECOMMENDATION

The NAVSEA DAC should initiate a study of the AEGIS Cruiser and other shipbuilding programs change data to identify improvements which can be made in the ship specification development process.

7. CONCLUSION

Reductions in the cost of building ships for the U.S. Navy can be realized in ship- building programs where the shipbuilder is directly involved in the preparation of the ships specifications.

DISCUSSION

It is readily understandable that any organization which is to be tasked to construct something, or carry out a task, will be able to perform the task more efficiently if that organization has participated in the task definition and its planning. This is the case with shipbuilders. As discussed in Reference [1] and [2], the shipbuilders' being involvement in the details of preparing the ship specifications does have a downstream cost benefit in lower ship construction costs.

The Navy has usually followed this policy when building the first of a new class of ships. Through competition the Navy will select a lead shipbuilder who will be contracted to design and construct the first ship of the class. Experience has taught the Navy that this is the most cost and time effective way to build the first ship of a class. For later ships, the need for competition in contracting forces the consideration of other shipbuilders. This usually results in difficulties whereby the second shipbuilder is tasked to build a ship using processes which fit the first shipbuilder's method of operation but do not necessarily work in the second shipyard.

Having the shipbuilder involved in the development of the ship specifications

will provide many opportunities to identify cost savings and reduce the ship construction costs.

RECOMMENDATION

The Navy should ensure that the shipbuilders are involved and responsible for the ship specification process. This will allow them to study the best construction plan alternatives and make their contribution to preparing ship specifications which support a construction strategy and plan.

8. CONCLUSION

Because of the current NAVSEA manpower reductions, NAVSEA resources to handle new construction problems and routine tasks, such as updating GENSPECs Chapters, is receiving a low priority.

DISCUSSION

The reduction in defense spending is having a direct impact on the personnel levels in the technical branches of NAVSEA. The NAVSEA technical codes are still responsible for providing the day to day technical support to resolve current fleet and maintenance problems. This is as it should be. Faced with this situation and the reduced naval shipbuilding activity, the tendency is to assign a low priorty to routine tasks such as updating their portions of the GENSPECs.

Now more than ever, it is important to recognize that maintaining the GENSPECs in a reasonably current status (1-2 year update) to maintain the Navy's technical shipbuilding "corporate knowledge" is important. The need to resolve the technical issues of the day is understood and necessary; however, without an appropriate level of resources assigned to the task, the GENSPECs will soon lose its technical credibility.

RECOMMENDATIONS

NAVSEA must ensure that an appropriate level of effort is applied to maintaining the GENSPECs.

9. CONCLUSION

In most shipbuilding programs, claims or REAs submitted as a result of defective specifications or design are relatively small. Most of these changes are as a result of a needed design change and are not as a result of a defective specification. None the less, charge of defective GENSPECs in a claim or REA is a convenient method of strengthening the shipbuilders position.

DISCUSSION

In Section lll we presented data obtained from the AEGIS shipbuilding program which categorizes contract changes according to the source of the change for the multi-year/multi-ship program. The AEGIS program had approved 3,510 engineering change proposals (ECPs) as of January 1992. Design improvements accounted for 23 percent of the ECPs and 26.6 percent of the total cost of these ECPs over about a ten year period.

A number of the other ECP categories reported for the CG-47 AEGIS cruiser program are related to making the ship comply with design requirements such as safety items, weight and KG reduction, test changes and shock requirements. However, these ECPs are not as a result of a defective specification but are usually caused by failure to meet a design criteria when preparing the detailed ship design.

All contract changes and ECPs are in theory the result of a deficiency in the shipbuilding contract specifications. Because of the length of time involved in the process of ship construction, from initial concept design through detailed design and

ship construction, there are many opportunities for design changes to occur. Weapons systems support requirements may change, new technology items are added and the results of actual fleet experience, such as the mining of the U.S. Navy ships in the Persian Gulf, require changes in ship specifications in order to ensure the product delivered to the fleet is the best ship possible. Controlling the impacts of these changes on the ship design is a budgeting and political decision for the Program Manager but is not usually a design specification deficiency.

Some shipbuilders have submitted broad or omnibus REAs for costs incurred by the overall number of design changes without being able to identify specification cost impacts. In some of these REAs, the GENSPECs will be included as a cause of the cost problem. in these cases the GENSPECs is a useful target in order to attack some of the broad GENSPECs requirements which may have been used in the individual ship specifications.

RECOMMENDATIONS

Where significant REAs occur which relate to the individual ship design specifications, they should be viewed for possible changes to the GENSPECs in the normal GENSPECs changes process as specified in Reference [4]. This is the current policy and procedure of NAVSEA.

10. CONCLUSION

NAVSEAINST 4121.1; Ship Specifications; Preparation, Review and Revision of; dated 9 April 1977 is over fifteen years old and should be updated.

DISCUSSION

While the process for the preparation of ship specifications described in the instruction is generally accurate, there have been significant organizational changes in NAVSEA (and old NAVSEC). If this instruction is to remain the policy direction as to how to prepare ship specifications, it should be updated.

RECOMMENDATION

NAVSEA should update and reissue NAVSEAINST 4121.1, Reference [3].

APPENDIX A

REFERENCES

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[5] "Strategic Plan for Improving the Ship Design, Acquisition and Construction Process", Vol I and II, Naval Sea Systems Command, June 1991.

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